ON THE CRUSTAL DEFORMATION AT IDE AND NEWLY CONSTRUCTED VOLUME AND AREA DILATATION METERS

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BY

Michio TAKADA

1. For the purpose of studying the forecast of earthquakes, the Disaster Prevention Research Institute of Kyoto University has been observing the crustal deformation by various instruments at 22 observatories in the country at present. In order to such study, under the guidance of Prof. K. Sassa, since 1951 the writer also has begun to observe the crustal deformation at Ide observatory, a reformed adit of an abandoned copper mine located at Ide-cho, Tsuzukigun, Kyoto Prefecture (135°49.5′ E, 34°47.9′ N). The adit is 1.3 m in width, 1.8 m in height and about 120 m in whole length. The observing room of about 2.3 m wide, 5.8 m deep and 6.0 m high is situated at the most sequestered part of the adit and at about 35 m in depth from the ground surface. In the observing room, the various extensometers, the tiltmeters, the discharge meter and thermometers are set up. The super-invar-bar extensometers consisted of 6 components and the tiltmeters with horizontal pendulum of Zöllner suspension type of these instruments have been set up since this observatory was founded. The values of instrumental constants are shown in Table 1. The results of observation by these instruments, the volume dilatation calculated from the observation by 3 components of "1", "2" and "3" which are set up in the direction along the rectangular co-ordinate axes, and then secular variations and the annual variations obtained from these results are shown in Fig. 1 [(A), (B), (C), (D, (E)]. Examining the variations of the curves, it is recognized that the annual variations show a periodic harmonical curve. The means of the annual variations for 6 years from 1955 to 1960, become a systematic periodical curve, as shown in Fig. 2.

2. As described above, the volume dilatation can be obtained from the linear strains ε_1, ε_2 and ε_3 observed by 3 components extensometers "1", "2" and "3" which are set up rectangularly in the direction of the co-ordinate axes. That is, the volume dilatation e can be calculated as follows,

$$e=\varepsilon_1+\varepsilon_2+\varepsilon_3 .$$

Table 1 List of instruments of Ide Observatory

Mark	Azimuth	Sensitivity
	Super-invar-bar extensometer	
		$(10^{-8}/mm)$
1	Vertical	5.54
2	Horizontal N88°E	4.92
3	Horizontal N2°W	10.74
4	Dip 50° N88°E	3.46
5	Dip 66° N2°W	2.78
6	Horizontal N77°W	2.30
	Horizontal pendulum type tiltmeter	
		$(10^{-2''}/mm)$
T.M. A	N45°E	2.0
T.M. B	S45°E	2.0

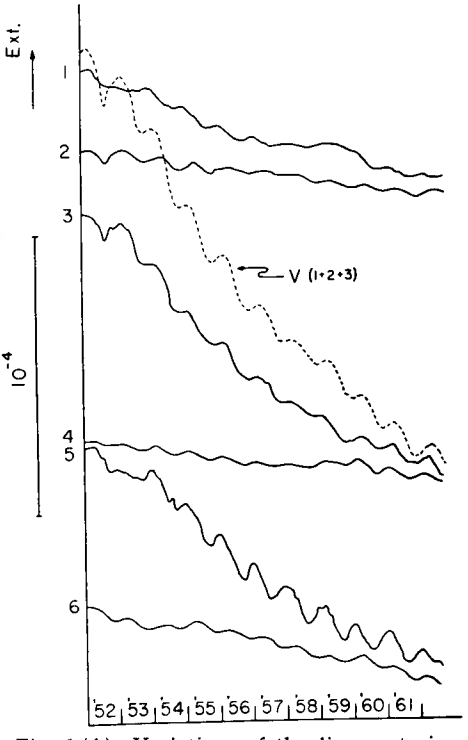

Fig. 1(A) Variations of the linear strains (——) and volume dilatation (· ·)

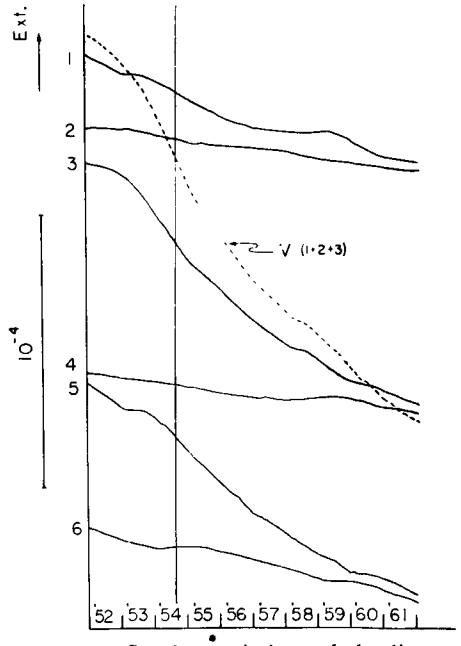

Fig. 1(B) Secular variations of the linear strains (——) and volume dilatation (· ·)

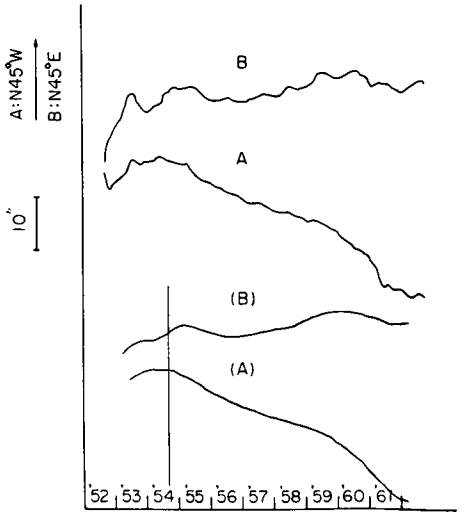

Fig. 1(C) Variations of the ground-tilt [*A*, *B*] and those secular variations [(*A*), (*B*)]

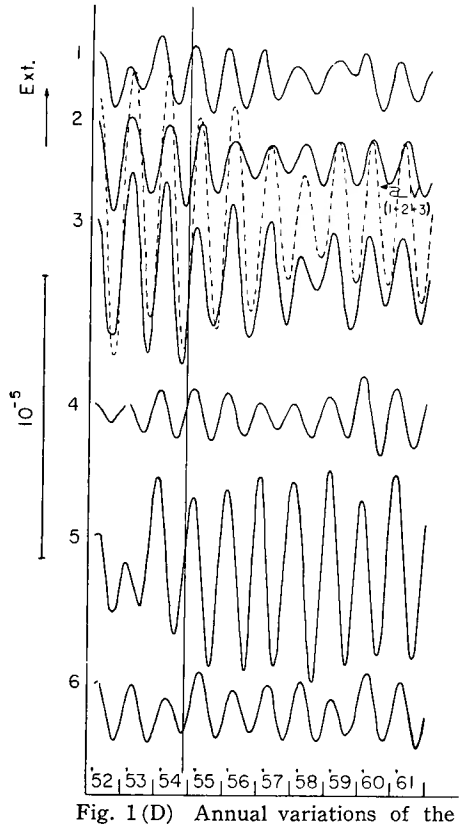

Fig. 1 (D) Annual variations of the linear strains (——) and volume dilatation (· ·)

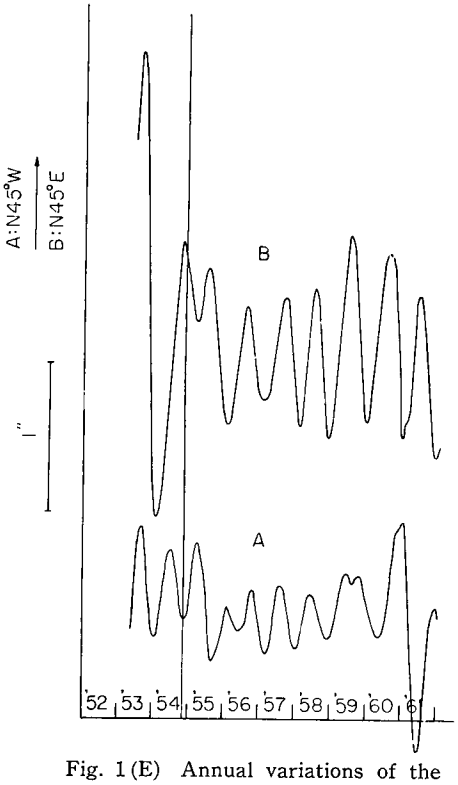

Fig. 1 (E) Annual variations of the ground-tilt

Also, the area dilatation can be calculated from the linear strains observed by 2 components which are set up rectangularly in the direction of the co-ordinate axes.

Subsequently, one terminal of the super-invar wire is fixed to the base rock and the other one is fixed to magnifying-device with bifilar suspension through a fixed pulley in the middle so as to make it possible to measure the combined strain in two rectangular directions. The measured strain obtained by this magnifying-device may show the area dilatation corresponding the relative variation of two fixed points. In the same way, when the super-invar wire is stretched in three directions along the rectangular co-ordinate axes with 2 fixed pulleys, the volume dilatation can be obtained from the extension rate of span between two fixed points of the natural base rock. Hence, a newly devised dilatation meter as shown Fig. 3[(A), (B)] was designed.

The instrumental constants are shown as follows.

Super-invar wire: 0.4 mm in diameter

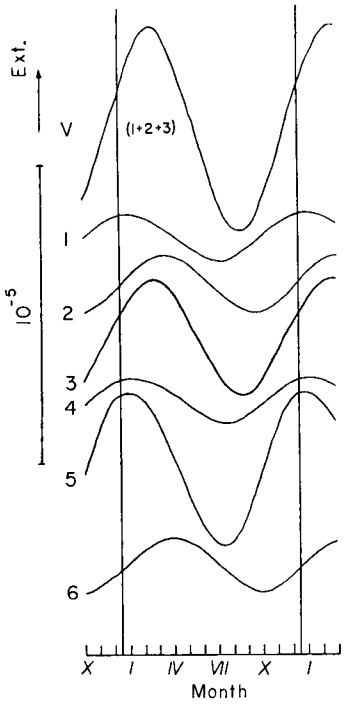

Fig. 2 Mean annual variations of the linear strains and volume dilatation

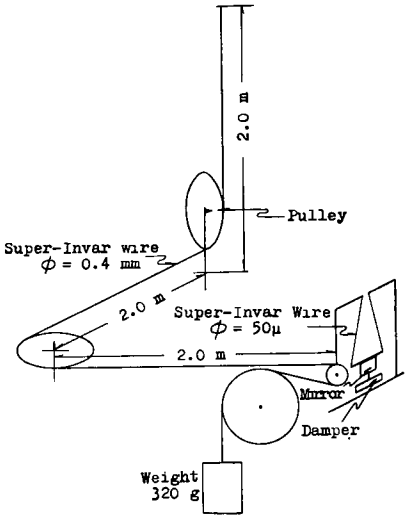

Fig. 3(A) Sketch of the volume dilatation meter

Measuring span in one direction: 2 m long

Pulley: 5 cm in diameter

Sensitivity { Volume dilatation meter: $2.5 \sim 1.6 \times 10^{-8}$/mm
Area dilatation meter : $3.3 \sim 1.4 \times 10^{-8}$/mm.

The result of the observation obtained by these instruments, the volume dilatation calculated from the linear strains "ε_1", "ε_2" and "ε_3" above mentioned and the area dilatation obtained from the linear strains "ε_2" and "ε_3" are shown in Fig. 4. Where the area dilatations are shown on the same horizontal plane. Comparing these, the variations observed by each extensometer and the variations calculated from the linear strains do not agree with each other at the latter term, in the strict sense. But both variations (specially secular variations) may be said to be in accordance with each other considering the nature of the observation of this kind. Because, the annual variation and the local variation are affected by the locality, on the whole, even where the places where the instruments are set up are near, and it is not so easy to obtain the exact sensitivities of these instruments, because of the high magnification.

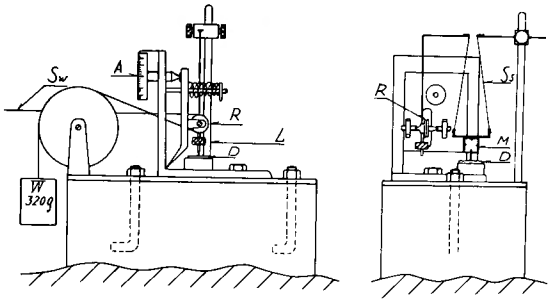

Fig. 3(B) Magnifying-device of the volume dilatation meter

S_w: Super-invar wire (0.4 mm in diameter),
Ss: Super-invar wire (50 μ in diameter),
M: mirror, W: weight, L: lamp,
D: damper, R: roller, A: adjuster

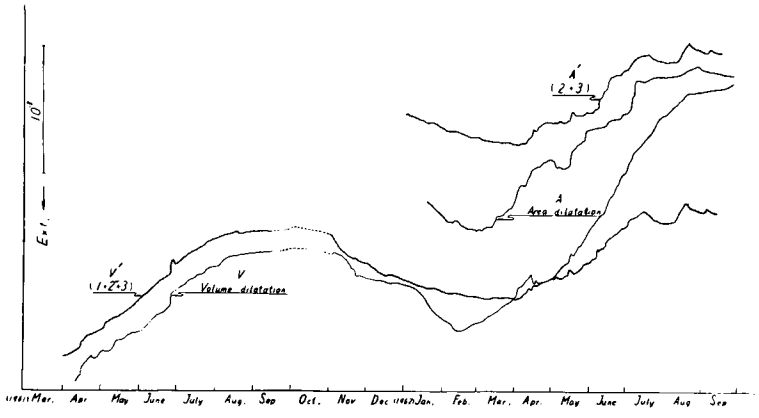

Fig. 4 Variations of the volume and area dilatation

V: Volume dilatation observed by the volume dilatation meter
V': Volume dilatation calculated from the linear strains
A: Area dilatation observed by the area dilatation meter
A': Area dilatation calculated from the linear strain

3. Photo. 1 shows the records observed by these instruments. As can easily be found from these records, the periodic variations are caused by the earth tide. Therefore, it is tried to obtain the lunner semi-diurnal constituent of the earth tide. In this case, first of all the zero line, or in other words, the secular variation should be obtained. The Pertzev's method is applied in this case. That is, firstly the

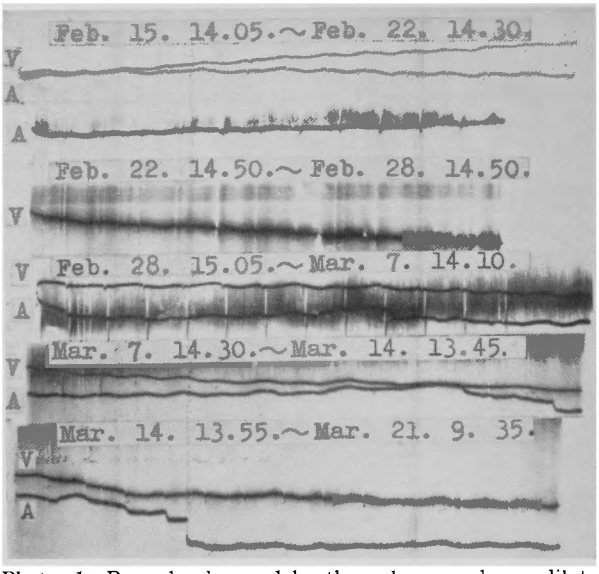

Photo. 1 Records observed by the volume and area dilatation meters

V: Volume dilatation, A: Area dilatation

reading of hourly values from the records, secondly the 15 hours' selected mean are taken. The series thus obtained is the secular variation, that is, the zero line. After that, the series of the hourly values eliminated the secular variation is analysed by the Darwin's method, by harmonic analysis. The results obtained for M_2-constituent by the harmonic analysis regarding data observed during from Feb. 17th to Mar. 16th 1962 are shown as follows.

$$\begin{cases} \text{Volume dilatation}: & 0.86\times\cos(2t-14.4^\circ)\times10^{-8} \\ \text{Area dilatation} & : 1.29\times\cos(2t-15.1^\circ)\times10^{-8} \end{cases}$$

(+: expansion).

In conclusion of this report, the writer wishes to express his cordial thanks to Prof. K. Sassa for his kind guidance and instruction all the time through out this study and also thanks to Prof. I. Ozawa, Prof. S. Yoshikawa and Dr. I. Nakagawa for their advices.